at minimum spacings.) This approach is still under discussion with PS/WP3 and will be further refined and suggested to the Systems Analysis Working Party SS/WP1 and Testing Working Parties PS/WP2 and SS/WP2.

VII. OTHER RECEIVER AND STANDARDS ISSUES

A. Receiver Technology And The Taboos

One conclusion stated in the FCC/OET TM88-2 report on receiver immunity and cited in Paragraph 72 of the Further Notice presumes that a new generation of TV receivers incorporating the technology demonstrated in the TI and RF Monolithics receivers could be produced and that Taboo-related interference is expected to be a problem only during a period of transition to such receivers.

We note that ATV receivers will be expected to receive both NTSC and ATV, for cost reasons through the same tuner if the ATV system permits this, and that the receiver must tune CATV channels to be broadly marketable. In our earlier comments in this docket(7) we observed that in the ten years since completion of the FCC/TI double-conversion receiver

(7) Comments of Zenith Electronics Corporation in Docket 87-268 dated November 17, 1988 at p. 11.

such a configuration has not been commercialized for broadcast television receivers in any of the world's markets. Some of the reasons cited were degradation of VHF performance, concern about achievement and control of UHF noise performance, incompatibility of the proposed first IF with the commercial requirements to tune CATV channels and the technology limitations of a still higher IF choice.

Zenith takes the position that the first front in reducing interference and the limitations of the Taboos is to properly tailor the ATV signal in relation to NTSC and the NTSC spectrum. The system we are proposing is so designed.

Even if useful double conversion solutions are found, even were known today, the introduction of ATV must not be saddled with a long transition period of interference to or from NTSC channels. Thus, the technology of the TI and RF Monolithic receivers should have no bearing on ATV decisions and their implementation.

B. Timing Of Spectrum And System Decisions

The Commission states at Paragraph 94 of the Further Notice "we see little benefit in deferring spectrum decisions until we reach a decision on technical standards issues."

Zenith believes that spectrum needs will be directly driven by the technical transmission standards adopted. Spectrum provisions and allocation specifics for a system utilizing simulcast, for example, will be necessarily different from those for a system utilizing augmentation of an NTSC channel. Even if one of the four system/spectrum options recited at Paragraph 83 were to achieve a favored status, firm spectrum decisions which result in implementation investments or assignment of spectrum to other services should not be made until fully operating systems have been tested and demonstrate the ATV performance and spectrum interference parameters expected.

A logical companion to system implementation work is a parallel FCC study and paper implementation of spectrum allocation proposals for the most promising scenarios, as discussed in Paragraph 96 of the Further Notice. This would both demonstrate allocation feasibility and permit prompt decisions when system development has been proven and Advisory Committee recommendations are made.

C. NTSC Standards

Zenith agrees with the comments summarized in Paragraph 107 and the conclusion of Paragraph 109 to the effect that the NTSC standard should not be relaxed or eliminated. We further concur with the policy and criteria recited in note

128 regarding waivers and experimental authorizations aimed at improvement of NTSC service.

Paragraph 109 proposes criteria for waivers of NTSC requirements for the purpose of broadcasting ATV signals. It is not clear whether the Commission intends to grant waivers to permit experimental transmissions or to permit ATV operation on a commercial basis. We oppose any ad hoc authorization of a commercial ATV terrestrial broadcast service. (Incidentally, we cannot believe the proposal is to authorize such an ATV service by waiver without regard to technical merit or public interest.) Authorizing commercial use of random ATV proposals and attendant marketing of receivers would significantly confuse consumers, dilute the impact of the system ultimately chosen by industry and the Commission, and may prejudge or unduly influence that decision. In the same sense that the Commission understands its mission to protect the public investment in NTSC receivers and services, so it could be obligated to perpetuate and protect any ad hoc defacto service so authorized.

D. ATV Standards

A Single Standard

Zenith strongly agrees with the arguments presented in

Paragraphs 113-114 on the merits of one well-defined published standard as essential for the successful and timely launch of ATV. Adopting a system as a "recommended" standard would be indecisive, encourage other alternatives, and would not further the introduction or acceptance of new technology.

Timing Of An ATV Standard

Comment is requested on timing of adoption of an ATV standard (Paragraphs 120, 122). Implementation of ATV will be greatly facilitated by broad acceptance and enthusiasm in the several affected industries. Ideally, the FCC should be responsive to an industry request for standardization. Pragmatically, given the Advisory Committee and its intent to recommend a system to the Commission, industry focus has shifted away from the ATSC to the Advisory Committee as a vehicle to sort through alternatives and choose a system. The Commission should await the recommendation of the Advisory Committee and assure that Committee the time necessary to carry its work to a thorough and accepted conclusion.

In any event, any standards action should be preceded by full system implementation and testing, including achievement of expected ATV and interference performance.

A Defacto Standard If Commission Does Not Act?

A defacto standard for terrestrial broadcast would require, at least, a laissez-faire approach by the FCC to authorize broadcast of ATV systems for commercial purposes. Thus, Commission "action" would certainly be required; a defacto broadcast standard cannot just happen.

A defacto standard would be most unlikely to derive from competition between systems. Investments in all segments of the business, including those required of the consumer, will not be justified by a fragmented market and the probability of obsolescence. It is possible that if the Commission were to acquiesce, a defacto standard could be bought - by concerted effort on the part of a few to promulgate a specific system by massive investments in programming, delivery, and receivers. The consequences of this would be further erosion of domestic industries, consumer uncertainties and longer time to significant penetration of ATV, and no expectation that either service quality or spectrum parameters would be those best serving the public interest.

Standards Flexibility

Paragraphs 116-118 discuss various standards alternatives which purport to enable future change in ATV

systems. These concepts all appear to derive from the thought that a published standard creates "inflexible requirements that prevent the development of newer, technically superior systems". New system development need not be inhibited by existing standards requirements; it is inhibited by the established service and product base. In the most glaring example, the NTSC was not deterred by the FCC field sequential color TV standards, and could expect acceptance in the absence of a color TV product base to be obsoleted.

The Commission has taken a wise and necessary decision to preserve the NTSC investments by consumers and the industries affected by ATV. Whether the regulatory introduction of ATV is by protection, recommended or allocation standards, a sunset standard or a normal mandatory standard, the Commission should not permit the later obsolescence or disenfranchising of a base of ATV receivers any more than it is willing to so treat the NTSC base. Thus, most of the possible regulatory methods are moot, enabling an improbable and unacceptable event.

A single mandatory standard should be established and future proposals treated on their merits. It should certainly be practical to draft a conventional standard for HDTV with sufficient flexibility to enable future change which retains operability of receivers designed to operate on the original HDTV standard.

ATV Receiver Flexibility

Some have proposed that one way to facilitate future change without obsoleting consumer equipment is to provide some degree of flexibility in the home receiver.(8) Comment is sought in the Further Notice (Paragraphs 119 and 122) on the concept of a so-called "open architecture" receiver. In the context of this Notice, the issue is the unqualified capability of a receiver to receive and decode more than one unspecified TV system as an alternative to promulgation of an ATV standard.

We assume "open architecture" refers to programmable flexibility or extensibility in signal processing capability of an appliance - e.g., TV set or computer. This can be done to provide specified excess, future, or adaptive capacity at baseband by

- built-in excess configurable capacity for computation and memory, or
- providing interfaces where modules providing the capability can be added within the receiver, or
- providing interfaces to add external modules.

(8) W. F. Schreiber, MIT. See note 19 of Further Notice.

This makes no provision for changes in the display format which may be required, especially by different scanning rates. And it makes no provision for reception of the TV signal by different transmission paths or transmission encodings.

Thus "open architecture" to accommodate forecast step-up or future options or enhancements to a specific system may be readily understood and implemented within, or by adding accessories to, the video and audio processing circuitry. The result of such adaptability could be to upgrade receiver performance if and when a system is upgraded, but adaptability should <u>not</u> be needed to retain the consumer investment in reception at the performance level originally purchased. Such system upgrades can be expected (and required) to be backwards compatible. The marketplace can be expected to provide appropriate hardware choices for the consumer.

However, such an "open architecture" baseband processor is unable to cope with reception of a different transmission format (in contrast to a baseband encoding format), requiring for example, reception of a second channel in an augmentation system, or requiring different IF channel and detection means because of the RF (and IF) modulation format. A receiver with one tuner will not provide a second tuner by "open architecture". A receiver expecting NTSC carriers and vestigial sideband modulation will not provide

by "open architecture" an entirely different IF passband and detection method to receive quadrature modulated carriers. Thus, accommodation of significant system differences beyond baseband processing would require hardware solutions and cost, known and anticipated in original receiver design.

The Advisory Committee Interim Report referenced "open architecture" in relation to the decoding of different (baseband) formats supplied by different delivery media - presumably known up front. In the context of the Further Notice, the unknowns are far more comprehensive and we can only make the same response as to the Interim Report(9):

> It is premature to advocate such receivers. We simply do not have enough information at this time to decide what degree of open architecture or adoptive components we would include in the receiver. History shows that receiver hardware that suits the real needs of the public will be in the market place when it is needed.
>
> Open architecture should not be the result of indecision on the part of the industry, the Advisory Committee or the FCC. This would inappropriately place the burden of ATV on receiver manufacturers - and ultimately, the buying consumer.

(9) Comments of Zenith Electronics Corporation on FCC Advisory Committee Interim Report, dated June 16, 1988 at p. 2.

The Further Notice also discusses receiver flexibility in the context of interoperability among alternative media, especially by means of standard interfaces. We support the conclusions of Paragraph 133 that when systems are defined the marketplace will provide interoperability and stimulate any necessary industry standards.

VIII. ECONOMIC AND CONSUMER ISSUES

It is far too early to form definitive conclusions with respect to specific equipment and operating costs for terrestrial ATV/HDTV transmission and reception. There are presently 21 system proposals, none of which have even been fully prototyped and tested, much less production designed and engineered. However, some general observations are in order and should be kept in mind in meeting the Commission's and the industry's objective of arriving at a standard for terrestrial HDTV broadcasting.

1. Development costs and capital requirements for any HDTV system will be higher than can be justified by near term return on investment prospects.

Beyond the not-insignificant costs of each system proponent in prototyping and testing its proposed broadcasting and receiving equipment, the product design and manufacturing facilitation costs of equipment to operate on the ultimately adopted single standard will be more onerous than those encountered with any previously adopted new-generation standard. Not only is the "chicken and egg" problem(10) a formidable one, but the U.S. consumer electronics industry finds itself in an unprecedented profitless condition at the outset. No television manufacturer with a U.S. presence has been able to operate profitably in recent years, even with the use of low-cost manufacturing operations in other countries. And so long as the U.S. market is permitted to remain a dumping ground for foreign products, profitability will not be restored, with or without HDTV. Even MTS stereo, which involves only enhancement of the existing NTSC standard and operates entirely within existing NTSC channel allocations, has achieved only a 25% TV receiver market penetration in five

(10) Profitability of video program production and broadcasting service operations must await the development of a mass audience, but consumers have little incentive to invest in costly receiving equipment until widespread HDTV service is available.

years. HDTV will impose a much higher premium on receiver cost, and even the most optimistic predictions project at least twice the time to reach a comparable market penetration. Even with appropriate government action to provide a level playing field for U.S. companies, a profitable return on investment in HDTV cannot be projected for at least ten years.

2. High definition pictures do not require wide screen displays.

Many discussions in the media and within the industry proceed on the tacit or explicit assumption that HDTV will usher in a new generation of wide screen TV products which will lead to the eventual obsolescence of the now-standard 4 x 3 format. There is no question that Zenith and the industry would find new wide screen TV products to be easier to differentiate and sell in the marketplace. At a given price range and all other considerations being equal, this would be an ideal scenario. However, prices and other considerations are far from equal.

High definition TV and wide screen display are two separate and distinct technological objectives. Each can be independently sought and achieved with or without the other. This does not mean that Zenith looks negatively on the 5 x 3 or 16 x 9 aspect ratios - only that high definition and wide

screen should each be separately subjected to its own cost/benefit evaluation.

3. The added costs of wide screen display, both to industry and to the consumer far exceed those of providing HDTV with the present 4 x 3 aspect ratio.

No existing U.S. manufacturing facility is realistically capable of producing large-screen 5 x 3 or 16 x 9 CRT display devices, even with extensive refacilitation or conversion. Major development costs and new facilities will also be required for glass envelope component production in the U.S. To facilitate production of such CRTs for even 25% of the U.S. color TV market would require an investment of billions of dollars even after incurring the heavy costs of new product development and specific new product designs. In the present ailing state of the U.S. consumer electronics industry, such multi-billion dollar investments can only be expected, if at all, if spread over many years.

This formidable economic deterrent to rapid adoption of HDTV can be greatly eased if the single standard to be adopted is tailored to provide HDTV service with displays embodying the present 4 x 3 aspect ratio. While requiring redesign for high resolution performance, such displays could use existing glass envelope designs and would require only minor modifications of existing CRT plants without

substantial reduction of U.S. industry capacity. Development costs and capital investment requirements for transmission systems and semiconductor components would remain substantial, but a profitable return on investment can be realized much sooner, and greatly enhanced picture performance can be delivered to a large number of consumers much earlier if wide screen displays are not incorporated in the standard to be adopted.

4. Wide screen picture display can only be achieved by sacrificing otherwise attainable further resolution improvement.

The added side panels of a wide screen picture display use a portion (e.g., 25% for a 5 x 3 display) of the video information spectrum space. This spectrum component could otherwise be available for transmitting more picture detail in a conventional 4 x 3 format. Picture performance is most important to consumers, as demonstrated not only by consumer surveys, but by the commercial success of features such as comb filters, RGB and Y/C jack packs, and HQ and Super-VHS video recorders, even when only available at a substantial cost premium. Building an HDTV standard around a 4 x 3 aspect ratio would provide the highest obtainable picture resolution.

5. Making wide screen displays an essential part of the HDTV standard will impose cost and performance penalties on consumers.

Most discussions of HDTV to date have focused on large screen receivers where the benefits of high definition are most evident. Largely overlooked has been the fact that new small screen TVs will also have to be capable of receiving HDTV transmissions. If the small screen sets are to reproduce complete wide pictures, they too will have to have 5 x 3 or 16 x 9 display devices, resulting in large percentage price premiums (up to 100% or more) for all sizes of HDTV receivers. Economy models can of course still be offered, using 4 x 3 displays, but the side portions of wide screen transmissions will necessarily be discarded in such receivers. Both large and small screen wide aspect ratio receivers will of course have blank bands at both sides of the screen when receiving NTSC transmissions, which will continue for many years just as black and white reruns continue now, nearly 30 years after the institution of color TV broadcasting. Blank bands in the display area, which may occur because of underscanning malfunction in NTSC receivers, expose transitional artifacts at the picture edges. Both the blank bands and the artifacts are highly objectionable to consumers.

SUMMARY AND CONCLUSION

Zenith applauds the Commission's decisions to develop a HDTV standard only after compiling actual test data for all qualified system proposals, to require non-obsolescence of the 160 million NTSC receivers in the hands of the public, and to require HDTV terrestrial broadcasting to operate within the present UHF/VHF television bands. Only the Zenith proposal meets all of these criteria, without artifacts in either NTSC or HDTV pictures, plus full compatibility with alternate distribution media, full spectrum compatibility with existing NTSC channel allocations, and ultimate release of current NTSC channel space for providing additional HDTV channels or other services.

Further, Zenith urges that high definition pictures and wide screen displays should be subjected to separate cost/benefit analyses. Zenith urges that, for better definition at an earlier time and at lower cost to the industry and to consumers, a 4 x 3 aspect ratio format should be considered as the HDTV standard. The Zenith system

proposal has been presented in a wide screen (5 x 3) context, in recognition of the widespread predisposition toward and expected marketplace appeal of wide screen displays, but is equally adaptable to present format (4 x 3) operation.

Respectfully submitted,

ZENITH ELECTRONICS CORPORATION

By _____

Robert B. Hansen
President, Consumer Products Group

John J. Pederson, Attorney
Zenith Electronics Corporation
1000 Milwaukee Avenue
Glenview, Illinois 60025

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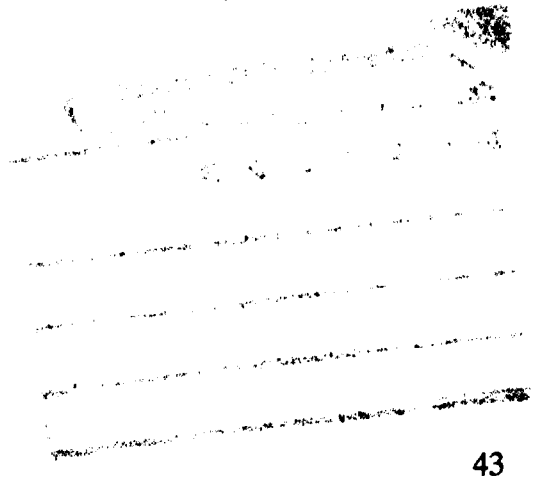

APPENDIX A

Proposed and Prepared by
The Electronic Systems Research & Development Department
Consumer Products Group

Zenith Electronics Corporation
1000 Milwaukee Avenue
Glenview, Illinois 60025

September 1, 1988

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ZENITH

SPECTRUM COMPATIBLE HDTV SYSTEM

EXECUTIVE SUMMARY

ZENITH'S
SPECTRUM COMPATIBLE HIGH DEFINITION TELEVISION SYSTEM

BACKGROUND

High definition television has generally been described as a new consumer-oriented television service having the properties of (1) improved picture definition, normally double in both horizontal and vertical resolution to that achievable by the existing NTSC system, and (2) improved audio, usually defined as compact disc (CD) quality. It is generally agreed that (3) improved noise performance is also required, and some believe that (4) wider aspect ratios are necessary. Although (5) larger screen sizes would probably best exhibit the improved resolution pictures, the marketplace will be the deciding factor.

The "ideal" HDTV signal would undoubtedly provide, as a minimum, properties (1) and (2) in conjunction with the existing NTSC signal, constrained to the current spectrum bandwidth of 6 MHz, such that viewers with a new, more expensive HDTV television receiver could receive HDTV video and sound while all 160 million existing NTSC receivers would receive their accustomed NTSC performance without any perceptible impairments. Such HDTV service is often called "compatible," "NTSC-compatible," or "receiver-compatible," analogous to the terminology used when compatible (with monochrome reception) color telecasts and receivers were first introduced in the late 1950's.

Such "compatible" HDTV systems have been proposed, but none are known to simultaneously satisfy the key criteria: double resolution; no impairments to NTSC reception within present NTSC service areas; utilization of only 6 MHz of bandwidth; and robustness to be transmitted and received through the 6 MHz terrestrial air-ways without deterioration resulting from noise, multipath (ghosts, airplane-flutter) and interfering spectrum emissions.

In attempts to meet all of the above criteria, others have proposed the use of more bandwidth (usually a total of 9 or 12 MHz) either via an auxiliary or "augmentation" signal of 3 or 6 MHz, or with an additional HDTV signal of 6 MHz to be broadcast simultaneously (the so-called "simulcast" approach) with the existing 6 MHz NTSC signal. Both approaches ("augmentation" or "simulcast") demand additional spectrum space. Those advocating such approaches, however, have offered no solution as to how that additional spectrum space can be achieved without negative impact on existing television or other communication services.

ZENITH'S SPECTRUM COMPATIBLE TRANSMISSION SYSTEM

Recognizing the dilemma of simultaneously having to satisfy the above performance, co-existence and spectrum-availability conditions, Zenith's research and development team set out to first design a new television **transmission system** capable of co-existing with the current NTSC system and the existing FCC-governed VHF/UHF channel allocations.

It is generally understood that many channels are not utilized in a given geographical area, and it is normally not possible to add new transmissions in the unassigned positions of the spectrum because of a large number of FCC-mandated prohibitions particularly in the UHF band. These non-available channel allocations are the result of the existing NTSC signal transmission format, the manner in which channels are allocated, and the limitations of the 160 million existing NTSC receivers. Normally, in most metropolitan areas, the spectrum utilization is restricted to every second VHF channel and every sixth UHF channel.

Reallocation of existing transmitters is not economical or popular. However, what can be done, when proposing a new HDTV system, is to change the transmission format (of the new signal only) and to change the receiver requirements (of the new receiver only) to enable more efficient use of the existing VHF/UHF spectrum.

The transmission and receiver formats of the Zenith HDTV system are suitably changed to enable utilization of today's unusable portion of the spectrum **with the result that every existing NTSC broadcast station can obtain a second 6 MHz channel over which a true HDTV program can be broadcast simultaneously with his existing NTSC program.** Thus, the Zenith system is spectrum compatible with existing NTSC signals.

An additional feature of the new, spectrum compatible HDTV transmission is that the required average transmitter power is less than 0.2% of that required by an NTSC transmitter with the same service area. Benefits to broadcasters of transmitter power consumption, transmitter hardware, antenna gain and/or antenna height will result.

FEATURES OF ZENITH'S SPECTRUM COMPATIBLE TRANSMISSION SYSTEM

The major feature of the new transmission format used by the Zenith system to enable the new, robust, spectrum compatible signal is the separation of the video picture information into two frequency bands. The video frequencies below 200 kHz are transmitted in a digital format while the video (picture) components having frequencies greater than 200 kHz are transmitted in analog format.

For all live video the energy associated with the high-frequency components is less than 1% of the total energy. That is, virtually all of the power associated with a video signal is contained in the low-frequency video information, the synchronization information (which is also low-frequency) and the average (or d.c.) value of the video. Thus, removal of the d.c. component (the picture carrier), the sync and low-frequency video components allows transmission of the high-frequency video components at substantially less power for signal-to-noise ratio performance better than that of NTSC, but with very small carrier power which causes less interference to other television signals, be they on the same channel, adjacent to the HDTV signal or located elsewhere in the VHF/UHF spectrum.

As much of the low-frequency information is transmitted redundantly in NTSC (i.e., the average value and sync information), it needs to be

transmitted far less-frequently (rather than continuously). Thus, this low-frequency information can readily be sampled, at a low rate, digitized and transmitted during the vertical blanking interval.

Signal robustness, which refers to the capability of Zenith's new system to be immune to interference from NTSC signals and to cause no interference to NTSC signals, is further enhanced by additional transmission processing (which includes companding, time dispersion and temporal filtering via field processing), appropriate spectrum selections (involving precise carrier frequency offset, frame synchronization and transmitter colocation within a service area, if required), and complete avoidance of subcarriers.

The information carrying capacity of the 6 MHz channel is maximized by use of in-phase and quadrature modulation of a suppressed carrier located in the center of the band. Centering of the carrier also improves signal robustness.

FEATURES OF ZENITH'S SPECTRUM COMPATIBLE ENCODING SYSTEM

Having a robust transmission system, it is then necessary to have a complementary video encoding system that facilitates transmission of the high definition information via the robust, 6 MHz spectrum compatible signal.

The basic technique to enable encoding of HDTV information (approximately 5 times as much information as used in NTSC) takes advantage of the visual properties of the human eye. Since the detail resolving capability of the eye is considerably less for objects in motion than it is for non-moving or stationary scenes, stationary video in the Zenith spectrum compatible system is transmitted at higher resolution than motion video. This encoding technique, when properly applied, translates the 30 MHz HDTV signal into a form suitable for transmission through a 6 MHz channel.

While the transmitted signal is made to resemble NTSC transmissions to aid the spectrum compatibility properties, the HDTV display on home receivers will be 787.5 lines, progressively scanned, with a field

(frame) rate of 59.94 Hz. The system is capable of providing pictures with width-to-height aspect ratios of 5:3, 16:9 or 4:3, with the marketplace making the ultimate decision. Extensive digital signal processing will be required in receivers, but it is anticipated that only one megabyte of field (frame) memory will be needed.

The HDTV source may be the 787.5 line, 59.94 Hz display format, or a 1050/59.94 source (progressive or interlaced), capable of providing 29 MHz R, G, and B signals.

The low-frequency video information, two channels of CD-quality audio and synchronization information are all digitized and transmitted during the 22.5 line vertical blanking period. Consistent with the ruggedness of the Zenith spectrum compatible system, the digital information is encoded using appropriate error-correcting codes. The digital audio is encoded using either of the two encoding systems proposed by Digideck or Dolby. A small amount of RF carrier is added back into the system to enable signal acquisition and tuning of the receiver.

APPLICATION TO CABLE, SATELLITE AND RECORDING

The reduced average power and peak power of the spectrum compatible system will also enable 6 MHz HDTV transmissions with improved interference and signal-to-noise ratio characteristics in cable systems, without rebuild of cable plants or decrease in the number of channels available.

Directly transcodable to FM signals used in satellite broadcasts, the new Zenith system will result in threshold improvement, and hence smaller receiving antennas (dishes) in the Direct Broadcast Satellite (DBS) environment. Furthermore, network-feed satellite transmission of HDTV can take place over existing NTSC links.

The HDTV signal is FM recordable in its encoded format. As only a 6 MHz bandwidth is required to record the full HDTV signal, minimum technology improvement (over S-VHS) is required.

The digital format of the transmitted signal is readily encodable to provide conditional access (security) in terrestrial, cable and satellite formats for those wishing to provide premium programming.

CONCLUSION

The Zenith Spectrum Compatible System provides a transmission and encoding system for HDTV that enables transmission of a 30 MHz HDTV signal through today's unusable portions of the VHF and UHF spectrum with the result that every existing NTSC broadcast station can obtain a second 6 MHz channel over which a true HDTV program can be broadcast simultaneously with his existing NTSC program. It is believed that no other proposed HDTV system can provide true HDTV picture and sound services within the current TV allocations without obsolescence of the existing 160 million NTSC receivers.

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